Polyphonic Murders

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Polyphonic Murders: A holographic biography of trauma

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ABSTRACT

This project is an innovative mixture of medical imaging and forensics with holography, animation, art and virtual reality. This alliance of art and science explores, presents and communicates the history of violence and the violence of history to diverse audiences. Anatomical detail provides the substrate for forensic analysis and interpretation while digital technologies and creative art nourish fictitious scenarios on unexplained historical crimes. The aesthetics of the virtual world create an immersive environment for diverse audiences. The emotional, ethical and aesthetic impact of violence becomes a site of reflection, empathy, learning and performative imagination.

1. Introduction

With causes ranging in scale from personal dispute to group conflicts and wars, violence has made its mark on every part of the history of humanity. The story of a violent event can be told as a tale, a song, a poem or a painting but the perception of violence is different when one is faced with a human body that suffered a cruel death. Skeletons bearing fatal injuries serve as hard evidence of violent acts, as archives, as numbers in a database, and as actors in an untold story. In many countries of the Western world, museums are keen to display human remains (mummies, skeletal remains, etc) as historical relics in part, and subjects of morbid curiosity in others. Egyptian mummies are displayed in several parts of the world while other human remains such as Native Americans are not exhibited anywhere due to a long history of debate and conflict about violating their religious freedom [1]. This indicates that there are different levels of sensitivity related to the public display of human remains that need to be respected. Yet, the public is always intrigued by stories of violent battles and murders from different historical contexts. This project combines historical cases of murder viewed through the prism of local artists, forensic anthropologists and human osteoarchaeologists in an attempt to identify and explore violence through both artistic and scientific means. Digital technologies, medical imaging techniques and three-dimensional printing combined with animation and virtual reality have given a new means of presenting sensitive information in a historical context without involving the display of human remains. Thus, the public can therefore engage with sensitive materials and their related histories in a different way.

Bringing together the language of sciences and arts, the conception of Polyphonic Murders was the product of a synergy: Kranioti's focus on forensic investigation of violence intermingled with Alexandros Papadopoulos' engagement with the aesthetics of crime. Papadopoulos [2–4] has explored both in theory and practice how various idioms of violence are retranslated into multiple modes artistic expression, in ways that often blur the boundaries between historical experience and representation, beauty and brutality, art and life. This understanding of violence as an intermedia vocabulary of aesthetics – one that cut across epochs and genres of creativity – formed the basis of the curatorial 'exegesis', informing the curational strategy, the creative co-ordination and the digital framing of the exhibition. Thereby this exhibition is not only a demonstration of original research – but also a proposition on the ways that collaborative practices-as-research can generate their own

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styles of knowing and understanding. In the resulting laboratory of truth and emotion, the 'factual', measurable features of science merge with the 'liquid' experiences of wisdom, intuition and imagination [5].

2. Material

Five cases of violent deaths were selected from the osteoarchaeological record of the Edinburgh Unit for Forensic Anthropology (EUFA) research group. The criterion to include the cases was that the skeletal evidence preserved on the skull showed possible homicides with severe trauma.

The analysis of every case was performed by the EUFA researchers (EK, JGGD, MK, LKG, IR, AB) following forensic anthropology methods commonly used to establish the biological profile [6], the nature of trauma [7], the possible weapons employed and the circumstances of death [8].

Case 1. Lundin Links beach, South-East Fife coastline, Scotland (UK), 450–650 CE. The Pictish cemetery of Lundin Links is located 20 km North-East of Edinburgh, Scotland. The cemetery was excavated in the 1960s and the skeletal remains have been subjected to multiple studies [9]. The most recent full assessment of the collection was undertaken in the 1990s and the excavation and the description of the skeletal collection was published in 2000 [10]. Skeleton LL3, from now on referred to as Case 1, originally survived as a largely complete skeleton although now only a skull and mandible can be associated with any certainty. The remains are housed at the McManus Art Gallery and Museum in Dundee. Skull morphology strongly suggests that this is a male individual, aged 35–45 years. Macroscopic and microscopic examination of the cranial skeleton revealed multiple blows to the back of the head with a sharp instrument such as a heavy axe or a sword.

Case 2. Can Peré Arabe, Ibiza, Balearic Islands (Spain), 100–700 CE. A double grave containing a possible female and a possible male, was found in a small assemblage of five burials belonging to the Roman Period. The possible female individual exhibited a circular perimortem defect in the right parietal bone consistent with a penetrating wound by a bodkin tanged arrowhead or a sling shot.

Case 3. St. John's College, Oxford city centre, England (UK), 1000–1100AD, Saxon period. This individual is one of the 40 individuals recovered from a mass grave representing the burial site of the victims of the St Brice's Day massacre. According to written sources, the Saxon King ordered the elimination of local settled Vikings who were subsequently ambushed and slaughtered. The victims were cornered at St Frideswide's Church and the building was set on fire. Skeleton SK1852 was a male individual, 16–25 years old, about 5 ft 8 inches in height [11]. The individual bears injuries from at least three different weapons (a sword, an axe and a spear) in his cranial and postcranial skeleton which is consistent with being attacked by multiple individuals.

Case 4. Whitefriars Carmelite[Friary, Perth, Scotland (United Kingdom) 1200–1600AD The individual is a possible male, 35–45 years old, approximately 5 ft 6 inches in height, who suffered a single strike to the head by a sharp object, with a square outline, around the time of his death.

Case 5. Trinity College in Dublin, Ireland, 1700–1900 AD (approximate). The skull is part of the 18th-19th century anatomical collection of Trinity College in Dublin [12]. Most of these skulls were obtained during a period in which skull collection was a popular 'scientific' pastime. Therefore, this collection includes skulls acquired as "gifts" from military campaigns (situations where heads were taken from battlefields as trophies), as well as those collected (generally illegally) by explorers, academics and missionaries throughout the world. The individual suffered at least eight strikes with a sharp thin bladed object(s) around the time of his death. The length of the mark varies depending on the area of the skull but the width and thickness are very similar and could have been caused by the same blade.

3. Methods

3.1. CT scanning

All skulls were scanned using medical CT scanners with slice thickness of 0.5–1 mm. Lundin Links was CT scanned at the Western General Hospital in Edinburgh, Scotland. Two dimensional images in *dcm* format were imported to Amira 6.4 software for segmentation (creation of 3D models) and visualisation.

3.2. Photogrammetry

One of the cases (Case 1) employed single camera Photogrammetry to capture the details of the skull and mandible using *Agisoft PhotoScan* software. This technique is based on capturing multiple photographs of an object from all possible angles and finally combing the 2D images in a scaled 3D model which contains texture information. An example of this photogrammetry 3D model can be seen in Fig. 1.

3.3. Animation and Holographic technology

Holographic technology is based on the physical principles of the diffraction of light to create full 3D images that can be viewed naturally without glasses. A digital hologram is produced from 3D data and manufactured using a special holographic printing machine or holoprinter [13]. The digital hologram is composed of a series of tiny holographic dots known as holopixels, usually around 0.7 mm in diameter. Each holopixel is encoded with a unique view of the scene as a diffraction pattern. The holopixel contains megabytes of information, requiring considerable graphics and image processing to compute all of these views. The holoprinter writes these holopixels into a photosensitive material using red, green and blue lasers, so the holograms are full colour. This material is a thin polymer sheet that is laminated on to a rigid acrylic backing. For viewing, the digital hologram requires a simple LED for illumination to bring out the 3D image. As we can control each ray of light emitted from the surface of the hologram, it is possible to include some limited animation within the hologram so we can view different images from different angles. This technology has been increasingly used in arts and sciences. Current applications of

Fig. 1. 3D Photogrammetry model of the cranium of Case 1 with realistic surface details.

Fig. 2. Hologram of the reconstructed traumatic event of Case 3 by Holoxica Limited.

digital holograms include military terrain visualisation, medical imaging, scientific data.

Presentation and architecture [14]. In our case holograms were created by Holoxica Limited company for the purpose of illustrating the mechanism of injury in the murder cases. An example of the hologram of Case 3 can be seen in Fig. 2.

In addition, *Holoxica Limited* created animations of the skull models and weapons with the motion of the weapon impacting the head of the individual in an effort to visualise the scientific interpretation of the traumatic injuries made by the scientists. Animations for each case can be found online in: http://www.holoxica.com/forensics/. The object can be manipulated (eg. rotation, zoom in and out) so that the user can observe the object from any angle and distance. An example of still images from Case 5 can be seen in Fig. 3. Fig. 4 illustrates the impact of three weapons in Case 4 from different angles and magnifications.

Fig. 4. The impact of three weapons in Case 4 from different angles and magnifications.

3.4. Virtual reality

Questions surrounding the theatrics, animation, and ethics arose early in the creative process when deciding how the Polyphonic Murders skulls should be presented. It was imperative that the skulls should be presented to the public in a way which was both respectful, but also interesting enough to catch the imagination of the audience. The experiences were created in Unreal Engine, a gaming engine which is both intuitive and powerful. Through this it was possible to create animated VR experiences specific to each case:

Case 1: The simplicity of Case 1 VR experience rested in the outstanding quality of the 3D model, due to the high-quality texture, a product of the method of photogrammetry previously described (see Fig. 1). This created a realism which was lacking in the other experiences. The viewer could walk around the model at eye level, and narration described the likely manner in which they sustained their injuries.

Case 2: In this case, the partial survival of the skull brought about a challenge in creating an experience which would describe how the fragment sat in the context of a skull, while maintaining focus on the injury. To understand the placement of the fragments a transparent 'ghost skull' was used, which the fragment sat within, allowing the fragments to remain the main focus of the experience, which concluded with an animated arrow inflicting injury to the skull (Fig. 5).

Case 3: The fragmented nature of this skull created the opportunity to show the audience how skulls are often not found intact, therefore

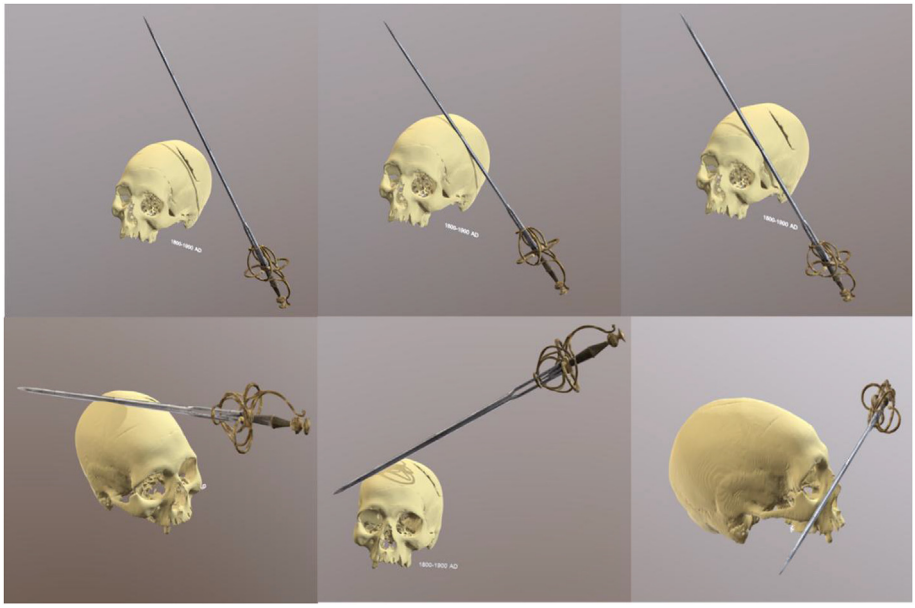

Fig. 3. Six still images from the animation tool produced by *Holoxica Limited* for Case 5, each illustrating a different injury caused by the same long thin-bladed weapon (similar to the example used in the animation for illustration purposes).

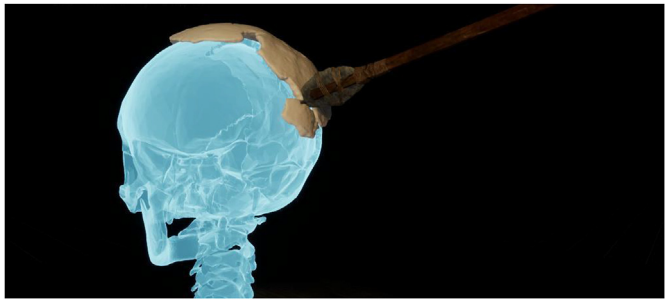

Fig. 5. Arrow inflicting injury in the back of the head in Case 2.

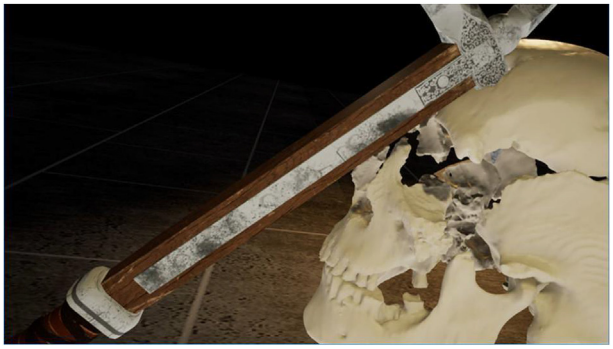

Fig. 6. Lateral view of Cas 3 with the inflicted trauma and the alleged weapon in a VR environment.

the experience began with the pieces moving together to form the skull, which had been supersized to create a more detailed experience. To try to convey the likely brutality behind this individual's death, the motion of the hammer which created the injury to the front of his head was animated, to dramatic effect (Fig. 6).

Throughout the three experiences, the viewer was able to walk freely around the skulls and dive inside them (Fig. 7). All experiences featured a dark background, a lit floor for context, and brightly-lit models to maintain focus on the skulls, rather than on the environment.

Fig. 7. VR experience at the Ocean terminal E-VR (with permission).

Fig. 8. Left: Transparent cranium and mandible of Case 1. Right: white cranial print with printed black arrow in Case 2.

The stories were narrated, then edited with a backing track using audio software Audacity. The project took place within E-VR in Ocean Terminal Shopping Centre (Edinburgh). The reactions to the three experiences were extremely positive, inciting conversations with the public surrounding the skulls themselves, as well as issues with the ethics of presenting human remains this way. Excitement was generated by Case 1 animation – standing inside an oversized skull is a novel experience-and the realism of the Lundin Links experience was shocking to even those experienced in VR.

3.5. 3D printing

Each case was 3D printed using a CTC bizer dual Fused Filament Fabrication printer and polylactic acid (PLA) material. White filament was used to make the models look more realistic (e.g. Fig. 8). For the purpose of the exhibition transparent filament was used to explore the application of different materials as well as the effect of the display on the viewer (e.g. Fig. 8). 3D printing of the models was done by Sotiris Katsimbas.

3.6. Exhibition

The exhibition took place between 17 and June 22, 2018 at the Ocean Terminal Mall. A unit designed for jewellery display was offered to us by the Ocean Terminal Management and provided an inspiration for setting up our material. The vitrines were used to position the 3D printed skulls and a series of possible weapons matching each case (Fig. 9).

Each case was accompanied by a fictional story presented in a form of a comic produced by the comic Artist Ioannis-Dimosthenis Artelaris (e.g. Fig. 10).

The interior of the exhibition housed artwork of several different artists such as Kristian Zara, Despina Nyssiriou, Spiros Borbas, Nadia Dermatopoulou and Samuel Garcia-Vargas.

A variety of artistic representations from video art to sculpture and photography “transformed an apparently dark idea into a polyphony of senses speaking out for past forgotten lives by shedding light to their untold stories” (quote from the exhibition statement). Examples of artwork can be seen in Figs. 11–15.

3.7. Questionnaires and feedback

Over the week of the exhibition, around a thousand visitors participated. Seventy-eight participants filled in a questionnaire about their experience. Below is a non-exhaustive list of questions and the most popular answers:

Fig. 9. Vitrines displaying (left to right – middle of picture) the 3D printer, and three white filament printed 3D skulls on stands. Above the skulls hang fictional depictions of the events that led up to each murder, whilst below the skulls, weapons similar to the probable murder weapons have been placed on stands.

Fig. 10. Comic poster by Ioannis-Dimosthenis Artelaris for Case 3.

Fig. 11. Video still from the work of video artist Nadia Dermatopoulou entitled *Thinking about murder (Video installation, back projection on tracing paper hanging from the ceiling)*.

1. Do you attend similar events regularly?

   Yes: 28.2% (22/78) No:73.1% (57/78).

2. What was your initial reaction to this event?

   Interested: 38.5% (30/78) Curious: 26.9 (21/78) Excited: 9% (7/78), Shocked: 1%
   (1/78), Bored: 0% (0), Multiple answers: 23.1% (18/78).

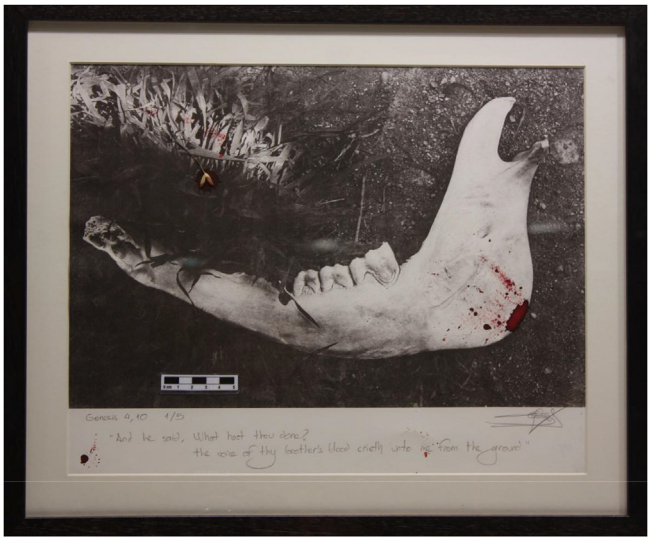

Fig. 12. Photolithograph in watercolour and collage, work of the photographer Samuel Garcia-Vargas entitled *Genesis 4:10. "And he said, What hast thou done? the voice of thy brother's blood crieth unto me from the ground".*

3. What did you find most interesting about this event?

   This section had very diverse comments such as.
   "The link between arts and science. And the way important scientific work is displayed in a relatable way for the audience."
   "VR experience and art installation! Very different."
   "Combining art science and history to tell stories about violence that are compelling rather than shocking."
   "The interactive methods used to story-telling".
   "How different ways of art can express different stories. How different perspectives and artist representation can stimulate imagination."
   "Skull holograms and hand-written portraits".
   "The set-up of the murder stories was the most impressive part for me".

4. Would you attend another similar event?

   Yes: 98.7% (77/78) No: 1.3% (1/78).

5. Why?

   Interesting/educative/interactive/fun:
   65.1% (50/78) No answer: 35.9% (28/78).

6. Would you recommend it to a friend?

   Yes: 100% (78/78) No: 0% (0/78).

7. Did this project get you to think any differently about history, heritage and technology?
8. How is that?

   This section had very diverse comments such as:
   "The multimedia approach to the forensic work has opened me to the possibility of understanding data that I wouldn't have access to otherwise."
   "About technology - I hadn't thought about how technology could inform and educate so deeply."
   "I think that involving people in many experiences like virtual reality, exhibition, talks can be a good way to make others know more about this field."

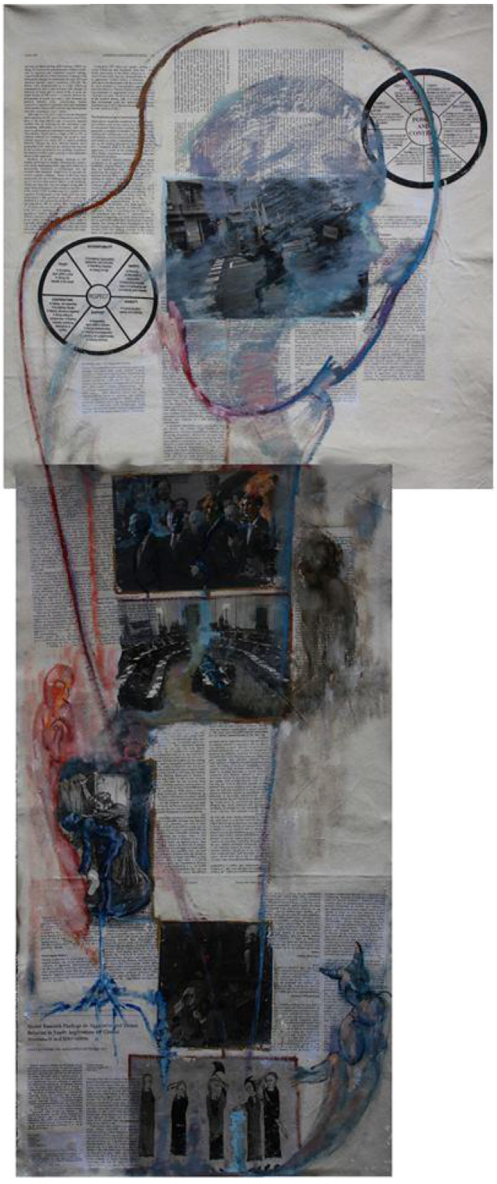

Fig. 13. Mixed media by Kristian Zara (60 × 180cm). His work is entitled Disintegrated shadow: *An artistic reflection upon violent actions over time. Evolutionary aspect of violence, from the psychic and emotional state to the sociological and political position.*

Fig. 14. The King's speech: Acrylic, pen on canvas (100 × 30cm) by Spiros Borbas.

"I have seen very vividly the evolution of the weaponry and trauma through history which I found very interesting."

"It helped me see more clearly how modern tech can be applied to learn more about the human skeleton."

"As a teacher, thinking of ways to engage children rather than telling them."

Fig. 15. Work by Despina Nissyriou: A collection from the Naval Hospital forest. Fragmented elements leaving ample space for your narrative (Material: Terracotta clay (unfired), gauge, PVA).

"How we can see and be with the past now for more reality/closer than before -so life-like."

7. Audience age ranges (77/78 answered this question)

< 18: 9.1% (7/77) 18–40: 50.5% (39/77), 40–60:33.8% (26/77) > 60: 6.5% (5/77).

8. Audience sex (75/78 answered this question)

Female: 56% (42/75), Male: 44% (32/75).

In addition to the visitors of the week-long exhibition some planned events took place on the first day. These included:

1. Forensic Investigation of violent deaths (booked 50/50 sold out)
2. Violence in Art (booked 27/40)
3. Time travelling assassins: An interactive game with children searching for supposed killers that came from different times and were hiding in the Mall (booked 28/40)

These events were booked using Eventbrite and some metric information is available:

1. A third (32%) of the audience rarely (< 1/year) go to science events compared to 36% who did it often (~once per month)
2. 46% rarely went to arts events compared to 32% who often went
3. 55% never or rarely went to archaeology events (5% never) compared to 41% who went sometimes (4/year) or 5% who went often!

4. Discussion

This paper presents the exhibition of five historical murders, which took place in a shopping centre (Ocean Terminal in Edinburgh) and involved different types of display and visualisation methods: 3D prints of skeletal injuries, associated weapons, animations of inflicted trauma, holograms, virtual reality experience for the murder cases, paintings, sculpture, photography and video art. The event included activities such as science and art presentations on the topic of violence, an interactive game for children (Time-travelling Assassins) and a test of

identification of simulated missing persons from reconstructed faces in drawings. The week-long exhibition attracted over 1000 visitors of diverse age, sex, ethnicity, educational background and socioeconomic status, due in part to the location of the event. Seventy-eight questionnaires were collected during the event, which asked questions about the use of digital technologies employed in the exhibition to present the violent stories. Both adults and children provided positive feedback highlighting the advantages of the different approaches used for the displays. Yet, only the adult opinions are reflected in the questionnaires as children often engaged in other activities rather than answering questions. Holograms and virtual reality allowed for a unique experience in which the visitor became embedded in the story. 3D prints were plastic physical objects that people could touch without the emotional burden that they would experience when handling human remains. Children engaged in the event by looking for our "assassins" (disguised students that were volunteering for the event) and left learning a story and holding a comic book.

The display of human remains has been, and is still, a controversial topic involving research, education and communities [15]. Fleshed (E.g. Body Worlds, London), mummified [16] or skeletonised remains [17] are displayed in different cultural institutions as part of permanent collections and temporary exhibitions all over the globe. They constitute an important tool for educational purposes helping the public to better understand the past and the present, not only through artefacts but also through osteological evidence [15]. Although such displays are a common practise, with institutions and museums often implementing strict policies on the ethical implications of their curation [18], many continue to object to the display of human remains from other cultures, such as trophy heads [19]. According to Swain [15] and the information gathered during the 2 days symposium about the value of human remains in Museum Collections (London, 2007), skeletons are one of the best informative materials among the different types of archaeological records supporting both historical context and medical research. In view of the limited access to the remains themselves and to prevent their deterioration, digital physical anthropology might present a solution offering new research opportunities to the academic community [20].

From the public point of view, the *Polyphonic Murders* exhibition demonstrated that new digital technologies offered alternative means of presenting to the audience the underlying anthropological research related to violence and trauma.

Overall, the presentation of these five cases to the public resulted in very positive feedback about the use of digital technologies for display purposes. The event engaged a striking percentage of people who would not normally attend archaeology events and families were positively surprised to find it child friendly. These cases could serve as a stepping stone towards the first virtual museum of violence worldwide with the potential of being accessible virtually, but also being able to display the event in different locations and countries. The use of such technologies minimizes the majority of ethical problems related to the display of human remains and allows for easier access and transportation of the material. It is hoped that the results of this study can contribute towards a review of existing policies on the display options of museums and galleries and help expand the means of dissemination of historical information.

Financial disclosure

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Ethics statement

This research is in line with the Recommendations for the Conduct, Reporting, Editing and Publication of Scholarly Work in Medical Journals. The Study was approved by the Ethics Committee of the University of Edinburgh. All participants in the questionnaires have consented in their use for research. Participants under 18 completed questionnaires with the permission of their legal guardians.

Declaration of competing interest

Authors declare no conflict of interest.

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